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(54) FACILITATING INVERSE MULTIPLEXING OVER ASYNCHRONOUS TRANSFER MODE VIA COMMUNICATION LINKS HAVING DISPARATE DATA TRANSMISSION RATES

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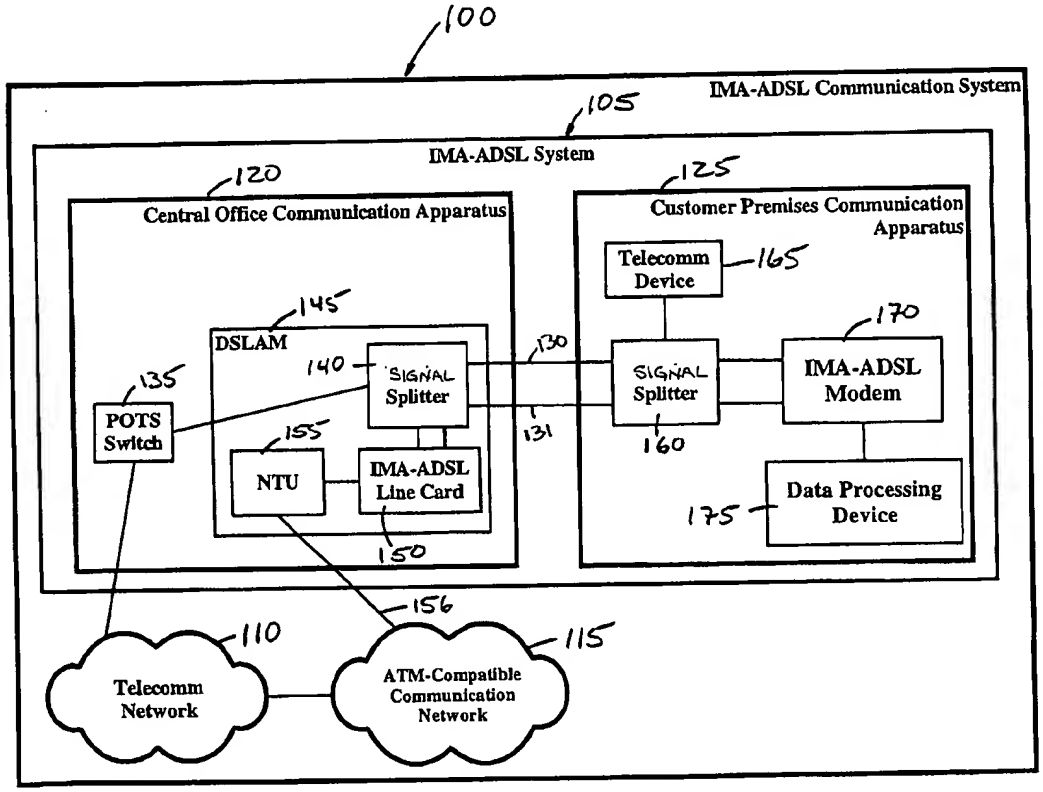
(57) ABSTRACT

A method for facilitating inverse multiplexing over asynchronous transfer mode is disclosed herein. The method includes receiving a stream of sequentially aligned ATM cells via an originating end point logical communication link. A sequence identifier is associated with each one of the ATM for creating sequence identified ATM cells. The sequence identified ATM cells are forwarded to an destination endpoint logical communication link in a distributed manner over a plurality of IM communication links. A first one of said IM communication links has disparate data transmission rates in at least one data transmission direction with respect to a second one of the IM communication links.



downstream data transmission rate. Accordingly, the inverse multiplexing techniques disclosed herein provide significant advantages relative to the conventional inverse multiplexing techniques.

[0032] Utilizing the IMA techniques disclosed herein, a first ADSL communication link is combined with one or more additional ADSL communication links that have disparate upstream and/or downstream data transmission rates relative to the first ADSL communication link. The result is a group of physically lower speed ADSL communication links that behave identically to a single point-to-point high-speed communication link of the same capacity as the group of lower speed ADSL communication links. In this, manner, increased data transmission rates can be achieved when cost or technical feasibility prevents deployment of a single high-speed point-to-point communication link. It is contemplated that the methods, systems and apparatuses disclosed herein may be useful with data communication links that have disparate data transmission rates, other than ADSL communication links.

EXAMPLE

Three IM-ADSL Communication Links

[0033] Data Communication is facilitated via three IM communication links. At a central office location, the communication apparatus the DSLAM is an ALCATEL ASAM Series unit having an IMA-ADSL line card capable of facilitating IMA functionality as disclosed herein. The DSLAM is connected to an IMA-ADSL modem at a customer premises via three separate twisted pair telephone lines connected through respective signal splitters at the central office and customer premises. The IMA-ADSL modem is capable of facilitating IMA functionality as disclosed herein. The three IN communication links are IM-ADSL communication links each implemented, over a respective one of the three twisted pair telephone lines.

[0034] The upstream and downstream data transmission rates (DTR) for a typical IM-ADSL communication link synchronized according to this example are depicted below in Table 1.

TABLE 1

	Downstream DTR	Upstream DTR
IM Link A	1.5 megabits/sec	300 kilobits/sec
IM link B	1.0 megabits/sec	400 kilobits/sec
IM link C	2.0 megabits/sec	600 kilobits/sec
Aggregate	4.5 megabits/sec	1.3 megabits/sec

[0035] In the preceding detailed description, reference has been made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration specific embodiments in which the invention may be practiced. These embodiments, and certain variants thereof, have been described in sufficient detail to enable those skilled in the art to practice the invention. It is to be understood that other suitable embodiments may be utilized and that logical, mechanical, chemical and electrical changes may be made without departing from the spirit or scope of the invention. For example, functional blocks shown in the figures could be further combined or divided in any manner without departing from the spirit or scope of the invention. To avoid unnecessary detail, the description omits certain information known to those skilled in the art. The preceding detailed description is, therefore, not intended to be limited to the specific forms set forth herein, but on the contrary, it is intended to cover such alternatives, modifications, and equivalents, as can be reasonably included within the spirit and scope of the appended claims.

What is claimed is:

1. A method for facilitating inverse multiplexing over asynchronous transfer mode, comprising:

receiving a stream of sequentially aligned ATM cells via an originating end point logical communication link;

associating a sequence identifier with each one of said ATM cells for creating sequence identified ATM cells; and

forwarding said sequence identified ATM cells in a distributed manner over a plurality of IM communication links, wherein a first one of said IM communication links having disparate data transmission rates in at least one data transmission direction with respect to a second one of said IM communication links.

2. The method of claim 1 wherein associating the sequence identifier includes determining a sequence code for each one of said ATM cells and inserting the sequence code for each one of said ATM cells into an information payload portion of a corresponding one of said ATM cells.

3. The method of claim 1 wherein associating the sequence identifier includes determining a sequence code for each one of said ATM cells and inserting the sequence code for each one of said ATM cells into a header portion of a corresponding one of said ATM cells.

4. The method of claim 1 wherein associating the sequence identifier is facilitated by an originating endpoint IMA-ADSL communication device.

5. The method of claim 1 wherein forwarding said sequence identified ATM cells in a distributed manner over a plurality IM communication links includes forwarding said sequence identified cells over a plurality of IM-ADSL communication links.

6. The method of claim 5 wherein:

a first one of said IM-ADSL communication links is synchronized at a first upstream data transmission rate; and

a second one of said IM-ADSL communication links is synchronized at a second upstream data transmission rate different than the first upstream data transmission rate.

7. The method of claim 5 wherein:

a first one of said IM-ADSL communication links is synchronized at a first downstream data transmission rate; and

a second one of said IM-ADSL communication links is synchronized at a second downstream data transmission rate different than the first downstream data transmission rate.

8. The method of claim 5 wherein:

a first one of said IM-ADSL communication links is synchronized at a first downstream data transmission rate and at a first upstream data transmission rate; and

a second one of said IM-ADSL communication links is synchronized at a second downstream data transmission rate different than the first downstream data transmission rate and at a second upstream data transmission rate different than the first upstream data transmission rate.

9. The method of claim 1, further comprising:

receiving said sequence identified ATM cells by a destination endpoint IMA communication device; and

forwarding an aligned stream of inversely multiplexed ATM cells across a destination endpoint logical communication link.

10. The method of claim 9 wherein receiving said sequence identified ATM cells includes holding at least a portion of said sequence identified ATM cells in a data storage device.

11. The method of claim 10 wherein forwarding the aligned stream of inversely multiplexed ATM cells includes sequentially retrieving said sequence identified ATM cells from the data storage device.

12. The method of claim 11 wherein sequentially retrieving said sequence identified ATM cells includes determining the sequence identifier associated with a plurality of said sequence identified ATM cells.

13. The method of claim 1, further comprising:

receiving said sequence identified ATM cells at a destination endpoint IMA communication device;

determining a next one of said sequence identified ATM cells to forward over a destination endpoint logical communication link; and

forwarding the next one of said sequence identified ATM cells over the destination endpoint logical communication link.

14. The method of claim 13 wherein determining the next one of said sequence identified ATM cells includes determining the sequence identifier for a plurality of sequence identified ATM cells.

15. The method of claim 13 wherein determining and forwarding are facilitated by the destination endpoint IMA communication device.

16. A method for facilitating inverse multiplexing over asynchronous transfer mode, comprising:

receiving a stream of sequentially aligned ATM cells via an originating end point logical communication link;

determining a sequence code for each one of said ATM cells;

inserting the sequence code for each one of said ATM cells into an information block a corresponding one of said ATM cells for creating sequence identified ATM cells;

forwarding said sequence identified ATM cells in a distributed manner over a plurality of IM communication links, wherein a first one of said IM communication links having disparate data transmission rates in at least one data transmission direction with respect to a second one of said IM communication links;

receiving said sequence identified ATM cells at a destination endpoint IMA communication device;

determining a next one of said sequence identified ATM cells to forward over a destination endpoint logical communication link; and

forwarding the next one of said sequence identified ATM cells over the destination endpoint logical communication link.

17. The method of claim 16 wherein forwarding said sequence identified ATM cells in a distributed manner over a plurality IM communication links includes forwarding said sequence identified cells over a plurality of IM-ADSL communication links, each one of the plurality of IM-ADSL communication links synchronized at disparate data transfer rates relative to each other one of the plurality of IM-ADSL communication links.

18. An apparatus for facilitating inverse multiplexing over asynchronous transfer mode (IMA), the apparatus including an originating endpoint IMA communication device, a destination endpoint IMA communication device, and a plurality of IM communication links implemented therebetween, a first one of said IM communication links synchronized at a disparate data transmission rate in at least one data transmission direction with respect to a second one of said IM communication links, the originating endpoint IMA communication device being capable of:

receiving a stream of sequentially aligned ATM cells via an originating end point logical communication link;

associating a sequence identifier with each one of said ATM cells for creating sequence identified ATM cells; and

forwarding said sequence identified ATM cells in a distributed manner over the plurality of IM communication links, wherein a first one of said IM communication links having disparate data transmission rates in at least one data transmission direction with respect to a second one of said IM communication links.

19. The apparatus of claim 18 wherein the originating endpoint IMA communication device being capable of associating the sequence identifier includes the originating endpoint IMA communication device being capable of determining a sequence code for each one of said ATM cells and inserting the sequence code for each one of said ATM cells into a information payload portion of a corresponding one of said ATM cells.

20. The apparatus of claim 18 wherein the originating endpoint IMA communication device being capable of associating the sequence identifier includes the originating endpoint IMA communication device being capable of determining a sequence code for each one of said ATM cells and inserting the sequence code for each one of said ATM cells into a header portion of a corresponding one of said ATM cells.

21. The apparatus of claim 18 wherein the originating endpoint IMA communication device is an originating endpoint IMA-ADSL communication device, the destination endpoint IMA communication device is a destination endpoint IMA-ADSL communication device and the plurality of IM communication links are a plurality of IM-ADSL communication links.

22. The apparatus of claim 21 wherein:

a first one of said IM-ADSL communication links is synchronized at a first upstream data transmission rate; and

a second one of said IM-ADSL communication links is synchronized at a second upstream data transmission rate different than the first upstream data transmission rate.

23. The apparatus of claim 21 wherein:

a first one of said IM-ADSL communication links is synchronized at a first downstream data transmission rate; and

a second one of said IM-ADSL communication links is synchronized at a second downstream data transmission rate different than the first downstream data transmission rate.

24. The apparatus of claim 21 wherein:

a first one of said IM-ADSL communication links is synchronized at a first downstream data transmission rate and at a first upstream data transmission rate; and

a second one of said IM-ADSL communication links is synchronized at a second downstream data transmission rate different than the first downstream data transmission rate and at a second upstream data transmission rate different than the first upstream data transmission rate.

25. The apparatus of claim 18 wherein the destination endpoint IMA communication device being capable of:

receiving said sequence identified ATM cells; and

forwarding an aligned stream of inversely multiplexed ATM cells across a destination endpoint logical communication link.

26. The apparatus of claim 25 wherein the destination endpoint IMA communication device being capable of receiving said sequence identified ATM cells includes the destination endpoint IMA communication device being capable of holding at least a portion of said sequence identified ATM cells in a data storage device.

27. The apparatus of claim 26 wherein the destination endpoint IMA communication device being capable of forwarding the aligned stream of inversely multiplexed ATM cells includes the destination endpoint IMA communication device being capable of sequentially retrieving said sequence identified ATM cells from the data storage device.

28. The apparatus of claim 27 wherein the destination endpoint IMA communication device being capable of sequentially retrieving said sequence identified ATM cells includes the destination endpoint IMA communication device being capable of determining the sequence identifier associated with a plurality of said sequence identified ATM cells.

29. The apparatus of claim 18 wherein the destination endpoint IMA communication device is capable of:

receiving said sequence identified ATM cells via at least two of the plurality of IM communication links;

determining a next one of said sequence identified ATM cells to forward over a destination endpoint logical communication link; and

forwarding the next one of said sequence identified ATM cells over the destination endpoint logical communication link.

30. The apparatus of claim 29 wherein the destination endpoint IMA communication device being capable of determining the next one of said sequence identified ATM cells includes the destination endpoint IMA communication device being capable of determining the sequence identifier for a plurality of sequence identified ATM cells.

31. An apparatus for facilitating inverse multiplexing over asynchronous transfer mode, the apparatus including an originating endpoint IMA-ADSL communication device, a destination endpoint IMA-ADSL communication device, and a plurality of IM communication links implemented therebetween, a first one of said IM-ADSL communication links synchronized at a disparate data transmission rate in at least one data transmission direction with respect to a second one of said IM communication links, the originating endpoint IMA-ADSL communication device being capable of:

receiving a stream of sequentially aligned ATM cells via an originating end point logical communication link;

determining a sequence code for each one of said ATM cells;

inserting the sequence code for each one of said ATM cells into an information block a corresponding one of said ATM cells for creating sequence identified ATM cells;

forwarding said sequence identified ATM cells in a distributed manner over a plurality of IM communication links, wherein a first one of said IM communication links having disparate data transmission rates in at least one data transmission direction with respect to a second one of said IM communication links; and

the originating endpoint IMA-ADSL communication device being capable of:

receiving said sequence identified ATM cells at a destination endpoint IMA communication device;

determining a next one of said sequence identified ATM cells to forward over a destination endpoint logical communication link; and

forwarding the next one of said sequence identified ATM cells over the destination endpoint logical communication link.

32. A data processor program product, comprising:

a data processor program processable by a data processor of an originating endpoint IMA communication device; and

an apparatus from which the data processor program is accessible by the data processor of the originating endpoint IMA communication device;

the data processor program being capable of enabling the originating endpoint IMA communication device to:

receive a stream of sequentially aligned ATM cells via an originating end point logical communication link;

associate a sequence identifier with each one of said ATM cells for creating sequence identified ATM cells; and

forward said sequence identified ATM cells in a distributed manner over a plurality of IM communication links to a destination endpoint IMA communication device, wherein a first one of said IM communication links having disparate data transmis-

sion rates in at least one data transmission direction with respect to a second one of said IM communication links.

33. The data processor program of claim 32 wherein the data processor program being capable of enabling the originating endpoint IMA communication device to associate the sequence identifier includes the data processor program being capable of enabling the originating endpoint IMA communication device to determine a sequence code for each one of said ATM cells and to insert the sequence code for each one of said ATM cells into an information payload portion of a corresponding one of said ATM cells.

34. The data processor program of claim 32 wherein the data processor program being capable of enabling the originating endpoint IMA communication device to associate the sequence identifier includes the data processor program being capable of enabling the originating endpoint IMA communication device to determine a sequence code for each one of said ATM cells and to insert the sequence code for each one of said ATM cells into a header portion of a corresponding one of said ATM cells.

35. The data processor program of claim 32 wherein the data processor program being capable of enabling the originating endpoint IMA communication device to forward said sequence identified ATM cells in a distributed manner over a plurality IM communication links includes the data processor program being capable of enabling the originating endpoint IMA communication device to forward said sequence identified cells over a plurality of IM-ADSL communication links.

36. The data processor program of claim 35 wherein:

a first one of said IM-ADSL communication links is synchronized at a first upstream data transmission rate; and

a second one of said IM-ADSL communication links is synchronized at a second upstream data transmission rate different than the first upstream data transmission rate.

37. The data processor program of claim 35 wherein:

a first one of said IM-ADSL communication links is synchronized at a first downstream data transmission rate; and

a second one of said IM-ADSL communication links is synchronized at a second downstream data transmission rate different than the first downstream data transmission rate.

38. The data processor program of claim 35 wherein:

a first one of said IM-ADSL communication links is synchronized at a first downstream data transmission rate and at a first upstream data transmission rate; and

a second one of said IM-ADSL communication links is synchronized at a second downstream data transmission rate different than the first downstream data transmission rate and at a second upstream data transmission rate different than the first upstream data transmission rate.

39. A data processor program product, comprising:

a data processor program processable by a data processor of a destination endpoint IMA communication device; and

an apparatus from which the data processor program is accessible by the data processor of the destination endpoint IMA communication device;

the data processor program being capable of enabling the destination endpoint IMA communication device to:

receive sequence identified ATM cells in a distributed manner via a plurality of IM communication links from an originating endpoint IMA communication device; and

forward an aligned stream of inversely multiplexed ATM cells across a destination endpoint logical communication link.

40. The data processor program of claim 39 wherein the data processor program being capable of enabling the destination endpoint IMA communication device to receive said sequence identified ATM cells includes the data processor program being capable of enabling the destination endpoint IMA communication device to hold at least a portion of said sequence identified ATM cells in a data storage device.

41. The data processor program of claim 40 wherein the data processor program being capable of enabling the destination endpoint IMA communication device to forward the aligned stream of inversely multiplexed ATM cells includes the data processor program being capable of enabling the destination endpoint IMA communication device to sequentially retrieve said sequence identified ATM cells from the data storage device.

42. The data processor program of claim 41 wherein the data processor program being capable of enabling the destination endpoint IMA communication device to sequentially retrieve said sequence identified ATM cells includes the data processor program being capable of enabling the destination endpoint IMA communication device to determine the sequence identifier associated with a plurality of said sequence identified ATM cells.

43. The data processor program of claim 39 wherein the data processor program being capable of enabling the destination endpoint IMA communication device to forward an aligned stream of inversely multiplexed ATM cells includes the data processor program being capable of enabling the destination endpoint IMA communication device to:

determine a next one of said sequence identified ATM cells to forward over the destination endpoint logical communication link; and

forward the next one of said sequence identified ATM cells over the destination endpoint logical communication link.

44. The data processor program of claim 13 wherein the data processor program being capable of enabling the destination endpoint IMA communication device to determine the next one of said sequence identified ATM cells includes the data processor program being capable of enabling the destination endpoint IMA communication device to determine the sequence identifier for a plurality of sequence identified ATM cells.

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